# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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|---|---|---|
| Applicant: | Min Wee Low et al. | Examiner: Unknown |
| Serial No.: | 10/598,390 | Group Art Unit: 2811 |
| Filed: | July 9, 2008 | Docket No.: I431.173.101/FIN588PCT/US |
| Title: | NON-LEADED SEMICONDUCTOR PACKAGE AND A METHOD TO ASSEMBLE THE SAME | |

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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We are transmitting herewith the attached:

☒ Transmittal Sheet containing Certificate of Mailing (1 pg.).

☒ Submission of Priority Document (1 pg.).

☒ Certified Copy of Priority Document PCT/IB2004/000496.

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By: Steven E. Dicke
Name: Steven E. Dicke
Reg. No.: 38,431

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By Steven E. Dicke
Name: Steven E. Dicke

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## SUBMISSION OF PRIORITY DOCUMENT

Commissioner for Patents
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Dear Sir:

Applicant claims priority under 35 U.S.C. § 119 to International Patent Application Serial No. PCT/IB2004/000496, filed February 26, 2004. A certified copy of the priority document is enclosed.

Applicant requests that the file of this application be marked to indicate that the requirements of 35 U.S.C. § 119 have been fulfilled and that the U.S. Patent and Trademark Office kindly acknowledge receipt of this document.

Respectfully submitted,

Min Wee Low et al.,

By their attorneys,

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Date: September 10, 2008
SED/mlm

Steven E. Dicke
Reg. No. 38,431

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By Steven E. Dicke
Name: Steven E. Dicke

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# PATENT COOPERATION TREATY (PCT)
# TRAITÉ DE COOPÉRATION EN MATIÈRE DE BREVETS (PCT)

## CERTIFIED COPY OF THE INTERNATIONAL APPLICATION AS FILED AND OF ANY CORRECTIONS THERETO

## COPIE CERTIFIÉE CONFORME DE LA DEMANDE INTERNATIONALE, TELLE QU'ELLE A ÉTÉ DÉPOSÉE, AINSI QUE DE TOUTES CORRECTIONS Y RELATIVES

International Application No. / Demande internationale n° PCT/IB2004/000496

International Filing Date / Date du dépôt international 26 FEBRUARY 2004 (26.02.04)

Geneva/Genève,

29 SEPTEMBER 2006 (29.09.06)

**International Bureau of the World Intellectual Property Organization (WIPO)**

**Bureau International de l'Organisation Mondiale de la Propriété Intellectuelle (OMPI)**

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G. Beijer
Head, PCT Receiving and Processing Section
Chef de la section de la réception et du traitement du PCT

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**PCT REQUEST**



Original (for SUBMISSION )

| | | |
|---|---|---|
| 0 | **For receiving Office use only** | |
| 0-1 | International Application No. | PCT / IB 0 4 / 0 0 4 9 6 |
| 0-2 | International Filing Date | 2 6 FEBRUARY 2004 (26. 02. 04) |
| 0-3 | Name of receiving Office and "PCT International Application" | INTERNATIONAL BUREAU OF WIPO<br>PCT International Application |
| 0-4 | **Form - PCT/RO/101 PCT Request** | |
| 0-4-1 | Prepared Using | PCT-SAFE [EASY mode]<br>Version 3.50 (Build 0002.153) |
| 0-5 | **Petition**<br>The undersigned requests that the present International application be processed according to the Patent Cooperation Treaty | |
| 0-6 | **Receiving Office (specified by the applicant)** | International Bureau of the World Intellectual Property Organization (RO/IB) |
| 0-7 | **Applicant's or agent's file reference** | FIN 588 PCT |
| I | **Title of Invention** | A NON-LEADED SEMICONDUCTOR PACKAGE AND A METHOD TO ASSEMBLE THE SAME |
| II | **Applicant** | |
| II-1 | This person is: | applicant only |
| II-2 | Applicant for | all designated States except US |
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| II-7 | State of residence | DE |
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| II-11 | Applicant's registration No. with the Office | 0.0 |

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| | | |
|---|---|---|
| III-1 | **Applicant and/or Inventor** | |
| III-1-1 | This person is: | applicant and inventor |
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| III-1-6 | State of nationality | SG |
| III-1-7 | State of residence | SG |
| III-2 | **Applicant and/or Inventor** | |
| III-2-1 | This person is: | applicant and inventor |
| III-2-2 | Applicant for | US only |
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| III-2-7 | State of residence | SG |
| IV-1 | **Agent or common representative; or address for correspondence**<br>The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: | agent |
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| IV-1-6 | Agent's registration No. | 0 |
| V | **DESIGNATIONS** | |
| V-1 | **The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.** | |
| VI-1 | Priority Claim | NONE |
| VII-1 | International Searching Authority Chosen | European Patent Office (EPO) (ISA/EP) |

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| VIII | Declarations | Number of declarations | |
|---|---|---|---|
| VIII-1 | Declaration as to the identity of the inventor | - | |
| VIII-2 | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent | - | |
| VIII-3 | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | - | |
| VIII-4 | Declaration of inventorship (only for the purposes of the designation of the United States of America) | - | |
| VIII-5 | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty | - | |
| **IX** | **Check list** | number of sheets | electronic file(s) attached |
| IX-1 | Request (including declaration sheets) | 4 | - |
| IX-2 | Description | 11 | - |
| IX-3 | Claims | 4 | - |
| IX-4 | Abstract | 1 | ✓ |
| IX-5 | Drawings | 2 | - |
| IX-7 | TOTAL | 22 | |
| | **Accompanying Items** | paper document(s) attached | electronic file(s) attached |
| IX-8 | Fee calculation sheet | ✓ | - |
| IX-11 | Copy of general power of attorney | | - |
| IX-17 | PCT-SAFE physical media | - | ✓ |
| IX-19 | **Figure of the drawings which should accompany the abstract** | 5 | |
| IX-20 | **Language of filing of the international application** | English | |
| X-1 | **Signature of applicant, agent or common representative** | | |
| X-1-1 | Name: | SCHWEIGER, Martin | |
| X-1-2 | Name of signatory | | |
| X-1-3 | Capacity | | |

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| | | |
|---|---|---|
| 10-1 | Date of actual receipt of the purported international application | 26 FEBRUARY 2004 (26.02.04) |
| 10-2 | Drawings: | |
| 10-2-1 | Received | |
| 10-2-2 | Not received | |
| 10-3 | Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application | |
| 10-4 | Date of timely receipt of the required corrections under PCT Article 11(2) | |
| 10-5 | International Searching Authority | ISA/EP |
| 10-6 | Transmittal of search copy delayed until search fee is paid | |

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| 11-1 | Date of receipt of the record copy by the International Bureau | |

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# A non-leaded semiconductor package and a method to assemble the same

The invention relates to a non-leaded semiconductor package and to a method of assembling a non-leaded semiconductor package.

US 6,498,099 discloses a method to produce a leadless semiconductor package by half etching one or both sides of the leadframe strip. After the wire bonding and molding processes, a further etching process is performed to isolate and expose the contact pads.

This process comprises many processes steps and, in particular, many etching steps. Etching is a slow and, therefore, expensive manufacturing process.

It is one object of the invention to provide a non-leaded semiconductor package and a simpler and more cost-effective method for producing the package.

This object of the invention is solved by the subject matter of the independent claims. Further improvements arise from the subject matter of the dependent claims.

A non-leaded semiconductor package is assembled using a leadframe strip assembly. A method to produce the leadframe strip assembly according to the invention comprises the following steps. Firstly, a metal foil is provided and a carrier tape attached to one surface. A plurality of leadframes is then formed in the metal foil, each leadframe comprising a die pad or die attach pad laterally surrounded by a plurality of con-

tact leads. Each leadframe comprises the design of the desired semiconductor package. Preferably, the plurality of leadframes is formed by an etching process which is, more preferably, performed from one side of the metal foil. A plurality of isolated individual leadframes is formed.

By performing only one etching process the manufacturing process according to the invention is simplified. Performing the etching process from only one side of the metal foil leads to a simplification of the equipment required to form the leadframes and lower manufacturing costs.

Alternatively, a plurality of leadframes is formed in the metal strip by laser cutting or stamping or any method known in the art. In this embodiment of the invention the leadframes are attached to each other by thin metal joining strips and form a continuous leadframe strip. The leadframe strip is then attached to the adhesive coating of a carrier tape. The metal joining strips are then removed by, for example, etching or by laser cutting to form a plurality of isolated leadframes attached to the carrier tape. The etching process is performed from only one side of the leadframe strip. This method has the advantage that the laser cutting or stamping process is relatively fast so that the manufacturing time is reduced.

The leadframe strip assembly according to the invention therefore comprises a metal foil attached to a carrier tape. The metal foil includes a plurality of leadframes preferably arranged in a regular array of columns and rows in the metal foil. Each leadframe comprises a die attach pad laterally surrounded by a plurality of contact leads. The arrangement of

the contact leads and the die attach pad relates to the desired package design.

Preferably, the die pad and contact leads of each leadframe of the leadframe strip include anchorage features. Typically, the side walls of the die pad and inner side walls of the contact leads include protruding portions formed by an approximately square cut-out section at the base of the side walls. The protruding portion therefore extends approximately horizontally from the side walls of the die attach pad and inner side walls of the contact leads and typically has an approximately square cross-section. The upper surface of the protruding portion lies on approximately the same plane as the upper surface of the die attach pad and contact leads. This protruding portion is the anchorage feature which advantageously improves the reliability of the package.

Preferably, the die pad and contact leads of each leadframe of the leadframe strip assembly are spatially isolated from each other and, preferably, each leadframe of the metal foil of the leadframe strip assembly is spatially isolated from its neighbour. The die pad and contact leads of each leadframe are laterally isolated and are not attached to each other. Each leadframe is also laterally isolated and is not attached to the neighbouring leadframes. The isolated leadframes are mechanically supported by the carrier tape. This arrangement of the leadframe strip assembly according to the invention is advantageous in that the cutting and stripping processes used in conventional leadframe manufacturing processes are avoided. This manufacturing line is therefore simplified.

Additionally, by isolating the contact leads, a space is created between adjoining leadframes. Therefore, during the singulation process the contact leads are not cut which is extremely advantageous.

Preferably, the carrier tape comprises a polyimide film with a silicone adhesive coating. This carrier tape material has the advantage that it has good heat resistance and, therefore, provides good mechanical support to the leadframes through the manufacturing process and, in particular, during the molding process. Also the adhesive can be cleanly removed from the bottom surface of the molded leadframe module or panel at the end of the manufacturing line just prior to the singulation of the individual semiconductor packages. This reduces the complex and costly cleaning steps.

Preferably, the metal foil comprises copper or aluminium or one of their alloys and more preferably comprises oxygen free high conductivity (OFHC) copper. These materials have good electrical conductivity, are relatively inexpensive and can be easily processed.

The metal foil preferably comprises a thickness of approximately 1 mm to approximately 0.01 mm or more preferably approximately 0.25 mm to approximately 0.1 mm. The leadframe strip assembly according to the invention is advantageous in that the thickness of the metal foil which is used to form the plurality of leadframes can be thinner than that used in conventional processes as the carrier tape provides mechanical support. Also, in the method according to the invention the whole surface area of the metal strip is not thinned by an etching process to create leadframes of the desired thickness.

The materials cost and manufacturing time is, therefore, reduced.

The leadframe strip may be partly or completely covered by an electro-plated coating. Different parts, such as the die attach pad, the contact leads and the contact areas of the contact leads, of a leadframe may be coated in different materials. The electro-plated coating may comprise silver, nickel/palladium/gold or nickel/nickel phosphorous.

In the next stage of the process a semiconductor die, which includes an active surface with a plurality of die contact pads and a passive surface, is attached to each die attach pad of the leadframe strip assembly. Each die is electrically connected to the leadframe by a plurality of bond wires connecting the die contact pads and the lead contact areas of the contact leads.

The plurality of dies attached to the leadframe strip assembly, contact leads, wire bonds and upper surface of the carrier tape are then encapsulated with mold material forming a panel or molded leadframe module. The mold material is typically a polymeric-based material.

A method to assemble a non-leaded semiconductor package according to the invention comprises the following steps. The panel or molded leadframe module formed by the leadframe strip assembly process is provided and the carrier tape attached to the bottom surface is removed. The individual non-leaded semiconductor packages are singulated from the panel by sawing.

The sawing process may be performed by a saw blade, water jet or laser. The leadframe strip assembly according to the invention provides a panel in which the packages are singulated by cutting through only the mold material as the leadframe strip assembly includes isolated leadframes, die attach pads and contact leads. This greatly simplifies the sawing process.

If a saw blade is used to cut through two different materials, cracks can form between the two materials, burr formation is a problem and the wear rate of the saw blade is increased. Water jet technology is extremely slow and, therefore, may be impractical for high volume production as it is too costly. If a laser beam is used to cut through two types of material then the intensity must be adjusted which leads to a complicated process. These problems are avoided by the leadframe strip assembly according to the invention.

The leadframe strip assembly and the method of the invention is advantageously used to produce very thin quad flat non-leaded (VQFN) packages and particularly for packages of the pancake design leadframe which include a plurality of adjoining leadframes.

An embodiment of the invention will now be described by way of example with reference to the drawings.

Figure 1 shows a non-leaded semiconductor package according to the invention,

Figure 2 shows a cross-sectional view of a section of a copper foil with a carrier tape according to the invention,

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Figure 3 shows a cross-sectional view of a section of the copper strip of Figure 2 after an etching process to form a plurality of isolated leadframes, each having isolated contact leads,

Figure 4 shows a cross-sectional view of a section of the leadframe strip assembly of Figure 3 after a die attach and a wire-bonding process,

Figure 5 shows a cross-sectional view of a section of the leadframe strip assembly of Figure 4 after a molding process, and

Figure 6 shows a cross-sectional view of a section of the leadframe strip assembly of Figure 5 during a singulation process.

Figure 1 shows a non-leaded semiconductor package 1 according to the invention. The package 1 comprises a semiconductor die 2 and a leadframe 3. The leadframe 3 comprises a die attach pad 4 in approximately its lateral centre which is laterally surrounded by a plurality of contact leads 5. The die attach pad 4 and contact leads 5 have essentially the same thickness and lie on essentially the same lateral plane. The inner ends of the contact leads 5 include lead contact areas 6. The side walls of the die attach pad 4 and the inner side wall of the contact leads 5 include a protruding portion 19 whose upper surface lies on approximately the same plane as that of the upper surface of the die attach pad or contact lead. The protruding portions 19 have an approximately square cross-section. The leadframe 3 comprises oxygen-free high conductivity copper.

The semiconductor die 2 includes an active surface with a plurality of die contact pads 7 and a passive surface. The pas-

sive surface of the die 2 is attached approximately in the lateral centre of the die attach pad 4 by die attach material 8. The die 2 is electrically connected to the leadframe 3 by a plurality of bond wires 9 which connect the die contact pads 7 and the lead contact areas 6.

The upper surface of the die 2, contact leads 5, bond wires 9 and space between the die pad 4 and contact leads 5 is encapsulated with mold material 10. The bottom surface 11 of the non-leaded package 1 comprises mold material 10 and the bottom surfaces of the die attach pad 4 and contact leads 5 on an essentially common plane. The outer side surfaces of the contact leads 5 are covered by a thin coating of the mold material 10. The outer sides of the semiconductor package 1 are essentially vertical. The bottom surfaces of the contact leads 5 provide the external contact areas of the package 1.

Figure 2 shows a copper foil 12 attached to a carrier tape 13 in the first step of the method according to the invention to manufacture very thin quad flat non-leaded (VQFN) packages. The copper foil comprises oxygen-free high conductivity copper and comprises a thickness of between approximately 0.25mm and approximately 0.1mm. The copper strip 12 is attached to the adhesive coating 17 on the upper surface of a carrier tape 13 which comprises a polyimide film substrate with a layer of silicone adhesive 17 on its upper surface.

Figure 3 shows the next stage of the method according to the invention in which a plurality of leadframes 3 are formed in the copper foil 1. The leadframes 3 formed by a selective etching process which takes place on one side, from the top as

shown in Figure 2, of the copper strip 12. The upper surface of the carrier tape 13 acts as an etch stop.

The leadframes 3 are laterally arranged in a regular array of rows and columns in the copper foil 12. Each leadframe 3 includes a die attach pad 4 in the centre which is laterally surrounded by a plurality of contact leads 5. The lateral arrangement of the plurality of leadframes and the lateral arrangement of each individual leadframe cannot be seen in the cross-sectional views of the figures.

The contact leads 5 are separate from the die attach pad 4 and are not connected to each other. Each leadframe 3 is laterally isolated from the neighbouring leadframes in the copper foil 12 and the bottom surface of each leadframe is attached to the adhesive coating 17 of the carrier tape 13. The carrier tape 13 provides the mechanical support to the isolated leadframes 3, each including an isolated die attach pad 4 and a plurality of isolated contact leads 5 during the next stages of the manufacturing process up to just prior to the singulation process.

In the next step in the process, shown in Figure 4, a semiconductor die 2 is attached using die attach material 8 to the die pad 4 of each leadframe 3 in the copper foil 12. The semiconductor die 2 includes an active upper surface including a plurality of die contact pads 7. The inner portion of each contact lead 5 of the leadframe 3 also includes a contact area 6. The electrical connection between the contact pads 7 of the semiconductor die 2 and the contact areas 6 of the contact leads 5 of the leadframe 3 is formed by wire bonds 9.

Figure 5 shows the molding process of the method according to the invention. The plurality of leadframes 3 is encapsulated by mold material 10 to form a molded leadframe module or panel 14. The die 2, die attach pad 4, contact leads 5, wire bonds 9 and areas between the contact leads 5, die attach pads 4 and the upper surface of the carrier tape 13 of each of a plurality of leadframes 3 are encapsulated by a single mass of mold material 10. The upper surface of the carrier tape 13 acts as the bottom surface of the mold. The mold material is then given an appropriate curing treatment.

Figure 6 shows the final step of the process in which the carrier tape 13 is removed from the molded leadframe module 14. The bottom surface 16 of the molded leadframe module 14 comprises mold material 10 and isolated areas comprising the bottom metal surfaces of the die attach pads 4 and isolated contact leads 5 on an essentially common surface. The individual non-leaded packages 1 are singulated from the molded leadframe module 14 by sawing through the mold material 10 between the individual leadframes 3 as indicated by the dotted lines 15 and saw blade 18.

Contacting means, such as solder balls, are then attached to the bottom surface of the contact leads 5 and provide the external contacts from the non-leaded package 1 to, for example, a printed circuit board. Alternatively, the solder balls may be attached to the contact leads 5 while the package forms part of the molded leadframe module. The packages 1 are then tested, packages and then mounted on, for example, a printed circuit board.

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Reference Numbers

1 non-leaded semiconductor package
2 semiconductor die
3 leadframe
4 die attach pad
5 contact lead
6 contact lead contact area
7 die contact pad
8 die attach material
9 wire bond
10 mold material
11 bottom surface of package
12 non-leaded package
13 carrier tape
14 molded leadframe module
15 singulation lines
16 bottom surface of leadframe module
17 adhesive coating
18 saw blade
19 protruding portion

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Patent claims

1. A method to assemble a leadframe strip assembly comprising the following steps:
   - providing a metal foil (12),
   - attaching a carrier tape (13) to the metal foil (12),
   - forming a plurality of leadframes (3) in the metal foil (12), each leadframe (3) comprising a die pad (4) laterally surrounded by a plurality of contact leads (5).

2. A method to assemble a leadframe strip assembly according to claim 1
characterized in that
the plurality of leadframes (3) are formed by an etching process.

3. A method to assemble a leadframe strip assembly according to claim 1 or claim 2
characterized in that
the etching process is performed from one side of the metal foil (12) forming a plurality of isolated leadframes (3).

4. A leadframe strip assembly comprising:
   - a carrier tape (13) including a metal foil (12) attached thereon,
   - a plurality of leadframes (3) formed in the metal foil (12) each leadframe (3) comprising a die pad (4) laterally surrounded by a plurality of contact leads (5) in the metal foil (12).

5. A leadframe strip assembly according to claim 4

characterized in that
the die pad (4) and contact leads (5) of each leadframe (3) of the metal foil (12) are spatially isolated from each other.

6. A leadframe strip assembly according to claim 4 or claim 5 characterized in that
each leadframe (3) of the metal foil (12) is spatially isolated from its neighbour.

7. A leadframe strip assembly according to one of claims 4 to 6
characterized in that
the carrier tape (13) comprises a polyimide film with a silicone adhesive coating (17) and the metal foil (12) comprises OFHC Cu.

8. A leadframe strip assembly according to one of claims 4 to 7
characterized in that
the metal foil comprises a thickness of approximately 1mm to approximately 0.01mm or approximately 0.25mm to approximately 0.1mm.

9. A leadframe strip assembly according to one of claims 4 to 8
characterized in that
the leadframe strip assembly further comprises a plurality of semiconductor die (2), each including an active surface with a plurality of die contact pads (7) and a passive surface, attached to the die attach pads (4) and electrically connected to the leadframe (3) by a plurality of

bond wires (9) connecting the die contact pads (7) and the lead contact areas (6) of the contact leads (5).

10. A panel (14) comprising a section of the leadframe strip assembly according to claim 9 characterized in that the plurality of dies (2), contact leads (5), wire bonds (9) and upper surface of the carrier tape (13) are encapsulated with mold material (10).

11. A method to assemble a non-leaded semiconductor package (1) comprising the following steps:
- providing a panel according to claim 10,
- removing the carrier tape (13), and
- singulating the non-leaded semiconductor packages (1).

12. A non-leaded semiconductor package (1) comprising:
- a leadframe (3) comprising a die attach pad (4) approximately in its lateral centre, laterally surrounded by a plurality of contact leads (5) each having a contact area (6),
- semiconductor die (2) including an active surface with a plurality of die contact pads (7) and a passive surface, attached to the die attach pad (4) electrically connected to the leadframe (3) by a plurality of bond wires (9) connecting the die contact pads (7) and the lead contact areas (6) of the contact leads (5),
- the upper surface of the die (2), contact leads (5), bond wires (9) and space between the die pad (4) and contact leads (5) being encapsulated with mold material (10),

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- the bottom surface (11) of the non-leaded package (1) comprising mold material (10) and the bottom surface of the die attach pad (4) and contact leads (5) on an essentially common plane.

13. A non-leaded semiconductor package (1) according to claim 12
characterized in that
the leadframe (3) comprises a thickness of approximately 1mm to approximately 0.01mm or approximately 0.25mm to approximately 0.1mm.

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Abstract

A method to assemble a non-leaded semiconductor package (1) comprises the following steps. A carrier tape (13) is attached to a metal foil (12). A plurality of leadframes (3) is formed in the metal foil (12), each leadframe (3) comprising a die pad (4) laterally surrounded by a plurality of contact leads (5). A semiconductor die (2), including an active surface with a plurality of die contact pads (7), is attached to each die attach pad (4) and electrically connected to the leadframe (3) by a plurality of bond wires (9) connecting the die contact pads (7) and the lead contact areas (6) of the contact leads (5). A plurality of leadframes (3), each including a wire bonded semiconductor die, are encapsulated with mold material (10). The carrier tape (13) is removed and the non-leaded semiconductor packages (1) separated.

[ Fig. 5]

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FIG 1

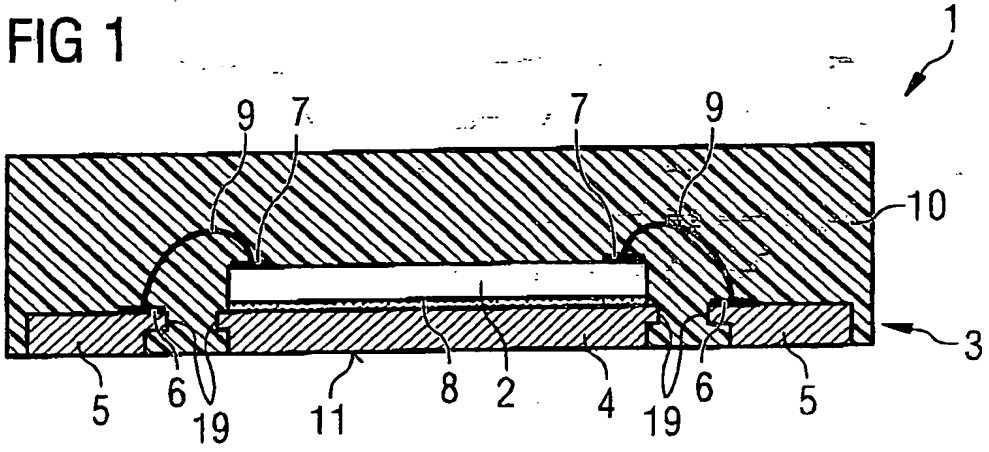



FIG 2

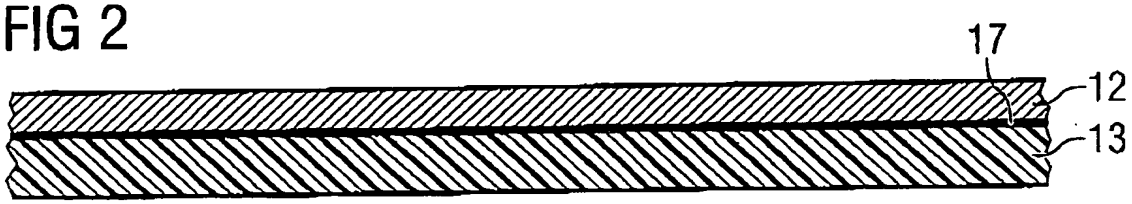
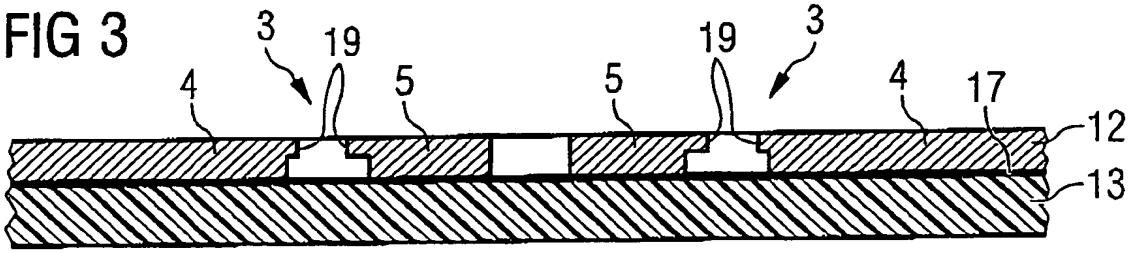



FIG 3



PCT/IB 0 4 / 0 0 4 9 6



FIG 4

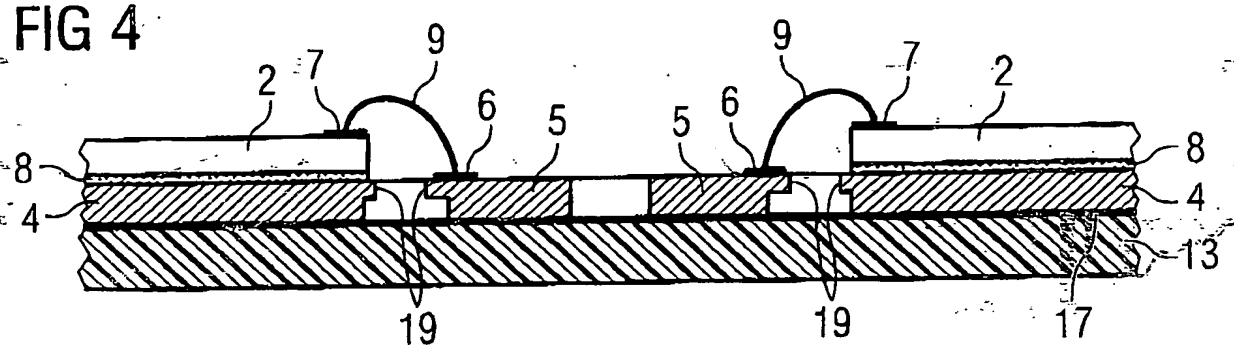



FIG 5

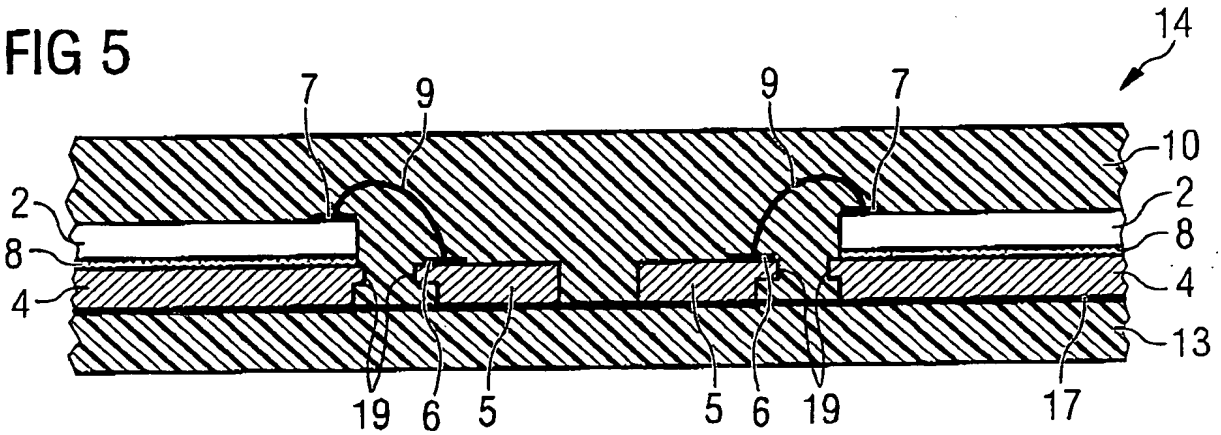



FIG 6